Claims

This Listing of Claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1. (Previously Presented) A membrane filtration apparatus comprising:

a plurality of membrane filtration modules, each membrane filtration module comprising:

a plurality of porous membranes extending in an array, said plurality of porous membranes encased in a support structure and having lower ends mounted in a lower pot supported by a lower header and upper ends mounted in an upper pot supported by an upper header, said upper header configured to provide for permeate to be withdrawn from said upper ends of said plurality of porous membranes; and

a plurality of distribution apertures defined in said lower pot, said distribution apertures configured to distribute a scrubbing fluid into said module and along a surface or surfaces of said membranes;

a single manifold coupled to said lower header of each of said plurality of membrane filtration modules; and

a single chamber positioned below, and connected to, said manifold, said chamber constructed and arranged to promote upward flow of feed liquid therethrough, said chamber comprising:

an open base end in fluid communication with a source of feed liquid;

a second end in fluid communication with said distribution apertures; and

a single gas inlet constructed and arranged to introduce gas into said chamber in a downward direction from above the open base end, said gas fed from above and through said manifold and into said chamber, said gas inlet centered between at least two of said plurality of membrane filtration modules and configured to release gas into said chamber at a position vertically displaced below said at least two of said plurality of membrane filtration modules,

said chamber configured to mix gas and liquid to produce said scrubbing fluid and further configured to distribute said scrubbing fluid to said distribution apertures.

2. (Previously Presented) The membrane filtration apparatus according to claim 1 wherein the chamber is elongate.

3. (Previously Presented) The membrane filtration apparatus according to claim 1 wherein the length of said chamber is greater than that required to provide a static head, when the membrane is immersed in a liquid and gas introduced into the chamber, equivalent to the head loss for the gas to flow to said distribution apertures.

4. (Canceled)

5. (Canceled)

6. (Previously Presented) The membrane filtration apparatus according to claim 1 wherein the chamber is enclosed on all sides.

7. (Canceled)

8. (Canceled)

9. (Previously Presented) The membrane filtration apparatus according to claim 1 wherein the chamber comprises a plurality of sides positioned to form a skirt directly beneath a header or plurality of headers.

10. (Previously Presented) The membrane filtration apparatus according to claim 1 wherein said plurality of membrane filtration modules are arranged in the form of an extended linear array, and wherein the chamber has enclosed long sides.

11. (Previously Presented) The membrane filtration apparatus according to claim 10 wherein the chamber has unenclosed short sides.

12. (Previously Presented) An assembly of membrane modules comprising:

a plurality of porous membranes extending in an array and having lower ends mounted in a plurality of lower pots supported by a plurality of respective lower headers, and upper ends mounted in a plurality of upper pots supported by a plurality of respective upper headers, said lower pots being configured to provide a number of distribution apertures therein for distributing a scrubbing fluid into said assembly of membrane modules and along a surface or surfaces of said membranes, said lower headers coupled to a manifold; and

a chamber positioned below and connected to said manifold, said chamber constructed and arranged to promote upward flow of feed liquid therethrough, said chamber comprising:

an open base end in fluid communication with a source of feed liquid;

a second end in fluid communication with said distribution apertures; and

a gas inlet constructed and arranged to introduce gas into said chamber in a downward direction from above the open base end, said gas fed from above and through said manifold,

said chamber configured to mix gas and liquid to produce said scrubbing fluid and further configured to distribute said scrubbing fluid to said distribution apertures.

13. (Previously Presented) The assembly of membrane modules according to claim 12 wherein the chamber is elongate.

14. (Previously Presented) The assembly of membrane modules according to claim 12 wherein the length of said chamber is greater than that required to provide a static head, when the membrane is immersed in a liquid and gas introduced into the chamber, equivalent to the head loss for the gas to flow to said distribution apertures.

15. (Canceled)

16. (Canceled)

17. (Previously Presented) The assembly of membrane modules according to claim 12 wherein the chamber is enclosed on all sides.

18. (Canceled)

19. (Canceled)

20. (Previously Presented) The assembly of membrane modules according to claim 12 wherein the chamber comprises a plurality of sides positioned to form a skirt directly beneath a header or plurality of headers.

21. (Previously Presented) The assembly of membrane modules according to claim 12 when arranged in the form of an extended linear array wherein the chamber has enclosed long sides.

22. (Previously Presented) The assembly of membrane modules according to claim 12 in the form of an extended linear array wherein the chamber has unenclosed short sides.

23. (Withdrawn) A method of removing a fouling material from a plurality of porous hollow fiber membranes mounted and extending longitudinally in an array to form a membrane module, the method comprising the steps of: providing a source of gas to a chamber in fluid communication with said membrane module; flowing the gas from the chamber into a base of the membrane module to form gas bubbles therein when said module is immersed in a liquid, whereby an upward flow of the gas bubbles across surfaces of the hollow fiber membranes is obtained, and whereby fouling materials are dislodged from the surfaces of the porous hollow fiber membranes.

24. (Withdrawn) A method according to claim 23 wherein the source of gas to the chamber is provided within the chamber.

25. (Withdrawn) A method according to claim 23 wherein the source of gas to the chamber is provided from below the chamber.

26. (Withdrawn) A method according to claim 23 wherein said chamber is elongate with one end open and the other end in fluid communication with the membrane module.

27. (Withdrawn) A method according to claim 26 wherein the gas is provided through the open

end of the chamber.

28. (Withdrawn) A method of removing a fouling material from a plurality of porous hollow fiber membranes mounted and extending longitudinally in an array to form a membrane module, the method comprising the steps of: forming a mixture of gas bubbles and liquid within a mixing chamber; injecting the mixture into a base of the membrane module, whereby an upward flow of the mixture across surfaces of the hollow fiber membranes is obtained, and whereby fouling materials are dislodged from the surfaces of the porous hollow fiber membranes.

29. (Withdrawn) A method according to claim 28 wherein the step of forming a mixture comprises entraining the gas bubbles into a liquid stream.

30. (Withdrawn) A method according to claim 29 wherein the gas bubbles are entrained into said liquid stream by means of the chamber.

31. (Withdrawn) A method according to claim 29 wherein the gas bubbles are entrained or injected into said liquid stream by means of devices which forcibly mix gas into a liquid flow to produce a mixture of liquid and bubbles.

32. (Withdrawn) A method according to claim 23 wherein air entering the mixing chamber is deflected.

33. (Withdrawn) A method according to claim 32 wherein air entering the mixing chamber is deflected by way of a T-piece or baffle.

34. (Withdrawn) A method according to claim 32 wherein air entering the mixing chamber is deflected away from liquid entering the mixing chamber by way of a nozzle.

35. (Previously Presented) A membrane filtration apparatus comprising:

a plurality of membrane filtration modules, each membrane filtration module comprising a plurality of porous membranes, said membranes being arranged in close proximity to one another and having lower ends mounted in a lower pot supported by a lower header and upper

ends mounted in an upper pot supported by an upper header, said upper header configured to provide for permeate to be withdrawn from said upper ends of said porous membranes;

a manifold coupled to said lower headers;

an open-ended mixing chamber constructed and arranged to provide a cleaning mixture by mixing together liquid and gas bubbles, said chamber immersed in a feed tank and having an open base in fluid communication with a source of feed liquid, said chamber constructed and arranged to promote upward flow of feed liquid therethrough;

a gas source positioned within the open-ended mixing chamber, the gas source constructed and arranged to introduce gas through a single gas inlet into the open-ended mixing chamber in a downward direction from above the open base, said gas fed from above and through said manifold and into said chamber, said single gas inlet centered within said plurality of membrane modules; and

means for flowing said cleaning mixture along a surface of said membranes to dislodge fouling materials therefrom.

36. (Withdrawn) A method of removing fouling materials from the surface of a plurality of porous hollow fibre membranes mounted and extending longitudinally in an array to form a membrane module, said membranes being arranged in close proximity to one another, the method comprising the steps of forming a mixture of gas bubbles and liquid within a mixing chamber, said mixture being formed by said gas bubbles being entrained in said liquid by flowing said liquid past a source of gas so as to cause said gas to be drawn and/or mixed into said liquid, flowing said mixture into said membrane module such that said bubbles pass substantially uniformly between each membrane in said array to, in combination with said liquid flow, scour the surface of said membranes and remove accumulated solids from within the membrane module.

37. (Withdrawn) A method according to claim 36 wherein the membranes comprise porous hollow fibres, the fibres being fixed at each end in a header, the lower header having one or more holes formed therein through which mixture of gas/liquid is introduced from the mixing chamber.

38. (Withdrawn) A method according to claim 37 wherein the holes are circular, elliptical or in

the form of a slot.

39. (Withdrawn) A method according to claim 36 wherein the membranes comprise porous hollow fibres, the fibres being fixed at each end in a plurality of headers, the lower headers being configured to provide a number of distribution apertures therebetween through which mixture of gas/liquid is introduced from the mixing chamber.

40. (Previously Presented) A membrane bioreactor comprising:

a plurality of membrane filtration modules, each membrane filtration module comprising a plurality of porous hollow membrane fibres extending longitudinally between and mounted between an upper and a lower potting head, said membrane fibres being arranged in close proximity to one another, said fibres being partitioned into a number of bundles at least at or adjacent to their respective potting head so as to form a space therebetween;

a header in which the lower potting head is supported;

a manifold coupled to the header;

an open-ended mixing chamber positioned below the lower potting head, said chamber constructed and arranged to promote upward flow of feed liquid therethrough, said chamber having an open base in fluid communication with a source of feed liquid; and

a gas inlet positioned within the open-ended mixing chamber, the gas inlet spaced from and surrounded by side walls of the open-ended mixing chamber and configured to feed gas into the open-ended mixing chamber from above and through said manifold,

wherein at least one of said potting heads includes an array of openings formed therein in fluid communication with said chamber constructed and arranged to provide gas bubbles within said module such that, in use, said bubbles move past the surfaces of said membrane fibres to dislodge fouling materials therefrom.

41. (Previously Presented) An assembly of membrane modules for use in a membrane bioreactor comprising:

a plurality of porous hollow membrane fibres extending longitudinally between and mounted between an upper and a lower potting head, said membrane fibres being arranged in close proximity to one another, said fibres being partitioned into a number of bundles at least at or adjacent to their respective potting head so as to form a space therebetween;

a header in which the lower potting head is supported;

a manifold coupled to the header;

an open-ended mixing chamber positioned below the lower potting head, said chamber constructed and arranged to promote upward flow of feed liquid therethrough, said chamber having an open base in fluid communication with a source of feed liquid; and

a gas inlet positioned within the open-ended mixing chamber, the gas inlet spaced from and surrounded by side walls of the open-ended mixing chamber, and centrally located within the open-ended mixing chamber and configured to feed gas into the open-ended mixing chamber from above and through said manifold;

wherein said potting heads are configured to provide a number of distribution apertures therebetween in fluid communication with said chamber for providing gas bubbles within said assembly of membrane modules such that, in use, said bubbles move past the surfaces of said membrane fibres to dislodge fouling materials therefrom.

42. (Previously Presented) The assembly of membrane modules according to claim 41 wherein the liquid used is feed to the membrane module.

43. (Previously Presented) The assembly of membrane modules according to claim 41 wherein the fibres within the module have a packing density of between about 5 to about 70%.

44. (Previously Presented) The assembly of membrane modules according to claim 43 wherein the packing density is between about 8 to about 55%.

45. (Previously Presented) The assembly of membrane modules according to claim 41 wherein said holes have a diameter in the range of about 1 to 40 mm.

46. (Previously Presented) The assembly of membrane modules according to claim 45 wherein said holes have a diameter in the range of about 1.5 to about 25 mm.

47. (Previously Presented) The assembly of membrane modules according to claim 41 comprising a deflector within said mixing chamber configured to deflect gas away from the source of the liquid.

48. (Previously Presented) The assembly of membrane modules according to claim 41 including a nozzle whereby liquid is introduced into the mixing chamber.

49. (Withdrawn) A membrane bioreactor comprising a tank having means for the introduction of feed thereto, means for forming activated sludge within said tank, a membrane module or an assembly according to claim 41 positioned within said tank so as to be immersed in said sludge and said membrane module provided with means for withdrawing filtrate from at least one end of said fibre membranes.

50. (Withdrawn) A method of operating a membrane bioreactor of the type according to claim 49, comprising introducing feed to said tank, applying a vacuum to said fibres to withdraw filtrate therefrom while periodically or continuously supplying a cleaning mixture of gas bubbles and liquid formed in a mixing chamber through said openings to within said module such that, in use, said cleaning mixtures flows along the surface of said membrane fibres to dislodge fouling materials therefrom.

51. (Withdrawn) A membrane bioreactor according to claim 49 wherein a further source of aeration is provided within the tank to assist microorganism activity.

52. (Withdrawn) A membrane bioreactor according to claim 51 wherein the membrane module is suspended vertically within the tank and said further source of aeration is provided beneath the suspended module.

53. (Withdrawn) A membrane bioreactor according to claim 52 wherein the further source of aeration comprises a group of air permeable tube.

54. (Previously Presented) The membrane filtration apparatus of claim 1 wherein said gas inlet is fluidly connected to a source of gas within said chamber.

55. (Previously Presented) The membrane filtration apparatus of claim 54 wherein said source of gas is coupled to a gas line which runs through said header.

56. (Previously Presented) The assembly of membrane modules of claim 12 wherein said gas inlet runs through said header.